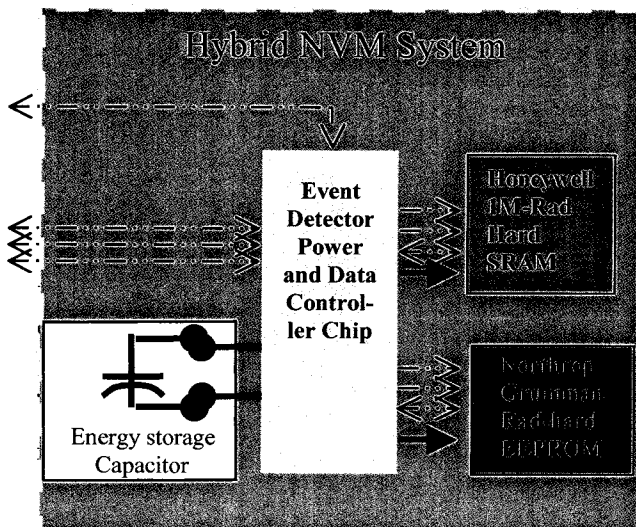


NONVOLATILE MEMORY SOLUTION FOR NEAR-TERM NASA MISSIONS: J.U. Patel, B. R. Blaes, M. M. Mojjaradi, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109 m/s 303-310 jupa-tel@jpl.nasa.gov

Introduction: Nonvolatile memory (NVM) system that could reliably function in extreme environments is one of the most critical components for many spacecrafts being developed for NASA missions to be launched in next 4 to 7 years. NVM supports the computer system in saving and updating critical state data required for a warm restart after power cycling or in case of a power bus failure. It also provides a power independent mass storage capacity for the scientific data gathered by the instruments. In some cases window for gathering such data is very small and occurs only once in a given mission. Commercially popular and fully developed Flash NVM technology is inappropriate for many reasons such as the limited read write cycles with slower access speeds, radiation intolerance, higher Single Event Upsets (SEU) rates etc. It is desirable to have an NVM systems based upon a robust cell technology making it immune to the SEUs and with sufficient radiation hardness. Availability of such NVM system seems to be still 5 to 10 years in the future.

Meanwhile, it is possible to provide an interim hybrid solution by combining the existing rad-hard technologies as shown in the Figure below.



Hybrid Solution for NVM system: The main components of our system are 1. Honeywell's Rad-hard SRAM and 2. Northrop Grumman's Rad-hard EEPROM connected by a Rad-hard ASIC that detects an event of power failure and controls data transfer between the SRAM and the EEPROM. Emergency data transfer is powered by the energy stored in the

super capacitor system. During the normal operation SRAM can take unlimited write cycles for the updating the data. Its only during an emergency event as detected by the system write operation is done on the EEPROM. Even though the EEPROM has a write cycle limitation of 10,000 to 100,000, the overall system offers an unlimited write cycle capacity with the data retention endurance of the EEPROM.

Proposed NVM solution seems even more attractive because the major components are already available except the Rad-hard ASIC which is very simple and could be fabricated within a year.

Characteristics and Reliability of Hybrid NVM Solution: As mentioned above, proposed NVM system offers unlimited write cycles with a reliable data retention endurance. It is also 300 Krad or better in radiation tolerance with extremely low SEU rates (1×10^{-10} SEUs/bit-day) compared to the Flash technology. Thus, it will require less shielding compared to the Flash option in planned missions such as the Europa in extreme radiation and temperature environments.

Operating life and reliability of the proposed NVM system is also enhanced by the Evans super capacitors which are already being used by the DoD in F-15 avionics systems. These capacitors provide the highest energy density and about 10^6 charge-discharge cycles over 15-20 years. Advanced packaging will be one of the requirements for this system since, the EEPROM chips are only 256Kb at present. But the road map of Northrop Grumman indicates 1 Mb chips in next two years.

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